PROJECT FACT SHEET

CONTRACT TITLE: In Well Imaging and Heating: Multiple-Use Well Design (PARTNERSHIP)

ID NUMBER: P-72 **B&R CODE**: AC1005000	**CONTRACTOR**: Lawrence Livermore National Laboratory Los Alamos National Lab **ADDR**: P.O. 808, L-208 Livermore, CA 94551
DOE HEADQUARTERS PROGRAM MANAGER: **NAME**: Elena S. Melchert **PHONE**: 202/ 586-5095 **DOE PROJECT MANAGER**: **NAME**: Rhonda P. Lindsey **LOCATION**: NPTO **PHONE**: 918/ 699-2037 **E-MAIL**: rlindsey@npto.doe.gov	**CONTRACT PROJECT MANAGER:** **NAME**: Robin NewMark **PHONE**: 925/ 423-3644 **FAX**: 925/ 422-3925 **E-MAIL**: newmark@llnl.gov
PROJECT SITE **CITY**: Livermore **STATE**: CA **CITY**: **STATE**: **CITY**: **STATE**:	**CONTRACT PERFORMANCE PERIOD**: 04/15/1998 to 03/31/2001 **PROGRAM**: Supporting Research **RESEARCH AREA**: Partnership/Drilling & Completion **PRODUCT LINE**: DCS

FUNDING (1000'S)	DOE	CONTRACTOR	TOTAL
PRIOR FISCAL YRS	530	850	1380
FISCAL YR 2000	0	0	0
FUTURE FUNDS	0	0	0
TOTAL EST'D FUNDS	530	850	1380

OBJECTIVE: Design and test multiple-use wells capable of producing fluids, accommodating steam injection, ohmic heating, and imaging the extent of these stimulation processes.

PROJECT DESCRIPTION:

Background: Current industry practice involves the construction of single-use wells, which are designed for exploration, production, injection (stimulation) or monitoring. Steam injection is a commonly-employed thermal enhancement. Typical steam floods require perforated injection wells separate from either production or observation wells designed to enable to process to be monitored. However, over the life of an oil field, it is often necessary to convert these wells to other uses (for example, to use production wells for injection or field monitoring). Multiple-use wells will permit more cost-effective operations, enabling operators to conduct and monitor stimulation efforts without requiring the installation of additional wells. What we propose is to increase the options available for an operator faced with managing a field in which thermal enhancements are probable.

LLNL has demonstrated expertise in subsurface electrical imaging, ohmic heating and both conducting and monitoring steam injection. LLNL was awarded a patent on the use of ERT for process control of steam injection, and has patents pending on electrode configurations and well designs for ohmic heating. The Nonisothermal Unsaturated-saturated Flow and Transport (NUFT) code is capable of simulating all the processes involved in this project.

Work to be Performed: We propose to design and test multiple-use wells capable of producing fluids, accommodating steam injection, ohmic heating, and imaging the extent of these stimulation processes. Ohmic heating has been used for thermal enhancement for both oil recovery and for environmental remediation purposes. Multiple electrodes placed on or part of an insulated well casing permit ohmic heating of the oil-bearing formation adjacent to the production well. An advantage of ohmic heating is that it does not require that production be interrupted as does steam flooding. Electrode separation, formation electrical and thermal conductivity contrasts, formation heterogeneity, groundwater and oil thermal diffusivity and well-production rate are variables that will affect the nature of heating in the formation near the well. We can model ohmic heating in a subsurface regime characterized by multicomponent (e.g., volatile oil, dead oil, water), multiphase (e.g., liquid, vapor) flow that can treat the effects of the variables mentioned above in 3D. We can also consider a variety of electrode geometries and electrical phasing arrangements; for example, electrodes connected to 3-phase or 6-phase ac power sources. In cases where oil wells are relatively close (10-50 m), it may be possible to heat the entire near-field regime by passing electric currents between the wells. However, such an electrode arrangement is not as amenable to high-resolution imaging. Numerical models of ohmic heating will be particularly helpful for interpreting such low-resolution results.

Electrical resistance tomography (ERT) is a technique that has proven valuable for characterizing the subsurface and for near real-time monitoring of processes that effect the electrical properties, such as the movement of fluids and heat. Although ERT imaging is usually performed using a crosswell configuration consisting of arrays of electrodes placed along insulating casings, we have developed the means for acquiring and interpreting data collected along a single borehole for near-well tomography. Cross-well tomography can also be performed using a single array along with existing metallic casing strings in the area; the metallic casings can be used as long electrodes and supplement the data from short electrodes within a single well. LLNL has a patent pending regarding the use of metallic casings as long electrodes for ERT. We plan to test both the axial imaging configuration and a modified cross-well tomography.

The new well design will incorporate LLNL's theoretical understanding and field experience, combined with practical input from our industry collaborators. Chevron, AERA Energy (a partnership between Mobil and Shell) and SteamTech Environmental Services are eager to participate, and have committed to contributing resources. The participation of SteamTech will insure that a vendor will be available to provide these services on a commercial basis.

PROJECT STATUS:

Current Work: This project is in its second year. During this year, work continues on parallel yet complementary paths: imaging, ohmic heating and engineering. The new deep imaging electrode strings installed in an oil field are being field tested, during steam injection and in combination with existing casings in the field. Parameter sensitivity studies are being carried out to develop an ohmic heating-optimized field design, to be constructed in collaboration with our industry collaborators.

Scheduled Milestones:

Field test cross-hole, high-resolution ERT	
Field test casing ERT configuration	2000
Determine optimum ohmic heating configuration	
Perform economic analysis for optimal recovery	
Develop ohmic heating-optimized field design	

Accomplishments: High resolution 4D crosswell electrical resistivity tomography (ERT) surveys are being conducted in an oil field under active steam flood. The electrode arrays constitute the deepest high-resolution ERT arrays installed, and their performance continues to be excellent. Crosswell ERT data continue to indicate changes occurring in individual formation units; these are being interpreted through correlation with occasional temperature measurements and production records. The changes can be interpreted in terms of both increasing temperatures and changes in fluid resistivities resulting from field operations. The resolution of these changes is much finer than that available from the production records.